Before the
Federal Communications Commission
Washington, D.C. 20554

In the Matter of

Comment Sought on Streamlining Deployment of Small Cell Infrastructure by Improving Wireless Facilities Siting Policies; Mobilitie, LLC Petition for Declaratory Ruling	))))	WT Docket No. 16-421

To: Office of the Secretary
Federal Communications Commission
Washington, DC 20554

Comment Filed by: The EMRadiation Policy Institute
P.O. Box 117
Marshfield VT 05658
E-Mail: info@emrpolicy.org
Telephone: (802) 425-3035

March 8, 2017

1. The EMRadiation Policy Institute (EMRPI) strongly endorses the Comment filed in this proceeding by Cindy Sage, MA; Lennart Hardell, MD, PhD; and David O. Carpenter, MD;

on behalf of The BioInitiative Working Group (BWG) (www.bioinitiative.org). BWG's Comment is included as Addendum I to this document. BWG's Comment reminds the FCC:

> The FCC is proposing to streamline the process for small wireless facility permitting **without completing its own[sic] investigation of RF health effects of low-intensity radiofrequency radiation** (emphasis added) (Docket No. 13-39, Docket No. 13-84 – In the Matter of Reassessment of Federal Communications Commission Radiofrequency Exposure Limits and Policies and Docket No. 03-137 – Regarding Human Exposure to Radiofrequency Electromagnetic Fields).

2. EMRPI strongly concurs with BWG's position that:

> This fact alone argues against the FCC speeding and easing the approval of millions of new 'small cell' wireless antenna sites under **Docket No. 16-421**. It also argues against permitting thousands of new satellite RF sources (Boeing **Docket No. 16-1244,** SAT-LOA-20160622-00058).

3. Since its founding in 2003, EMRPI has filed numerous Comments and Reply Comments in FCC proceedings. See: https://www.fcc.gov/ecfs/search/filings?q=filers.name:(*The%20EMR%20Policy%20Institute*)&sort=date_disseminated,DESC and https://www.fcc.gov/ecfs/search/filings?q=filers.name:(*The%20EMRadiation%20Policy%20Institute*)&sort=date_disseminated,DESC . EMRPI's filings are incorporated in this Comment by reference.

4. EMRPI's submittals repeatedly raise the question of the validity and relevance of the FCC's current RF safety limits for human exposure to address the exponential rise in the American public's chronic, repeated, full-body exposure to low-intensity RF emitters, both devices and infrastructure. It is well documented in EMRPI's submittals that the peer-reviewed scientific literature upon which the FCC's RF safety limits are based was published prior to 1986. This literature also lacks studies of the very frequencies that will be deployed for 5G and the Internet of Things (IOT).

5. In the FCC proceeding in question, i.e., WT Docket No. 16-421, at page 4, the FCC describes characteristics of small cell. i.e., DAS facilities and the ability for these RF emitters to be "located close to end users".

At footnote 16:

> … Antennas and associated equipment deployed at each small cell site or DAS node are physically much smaller than those at a microcell site and do not require the same elevation; therefore they can be placed on light stanchions, utility poles, building walls and rooftops, and other small structures either on private property or in the public rights of way **without creating the visual and physical impacts** (emphasis added) of microcell towers.

At footnote 17:

> . . . The coverage of small cells varies between 10 meters to several hundreds of meters, as opposed to the tens of kilometers served by macrocells.

At para. 1:

> . . . S&P Global Market Intelligence estimates that between 100,00 and 150,000 small cells will be constructed by the end of 2018, and that small cell deployments are expected to reach 455,00 by 2020 and nearly 800,000 by 2026.

6. EMRPI asserts that the impacts of this massive increase in RF-emitting facilities buildout does not end with the "visual and physical impacts" of attaching small-sized RF emitters to buildings and other structures in neighborhoods. Whether or not these small emitters catch the eye is of minor consequence to the question of the public's health and welfare. The collateral consequence of installing these RF emitters "close to end users" and the accompanying exponential rise in the level of RF exposure to user and non-user alike is the "physics" impact of 5G and IOT facilities buildout when it interacts with the biology of humans, wildlife and the environment. The pre-1986 peer-reviewed science the FCC relies on for its RF safety policies does not address RF exposures to living human beings and the environment at the frequencies that will be deployed, nor in continuous proximity to this density of RF emitters.

7. Given this exponential increase in ubiquitous RF exposure that will accompany small cell buildout and given that the FCC has not completed its examination of the efficacy of its RF human exposure policies, the FCC's proposal to speed up facilities buildout is woefully premature. EMRPI reminds the FCC of its statement in FCC 13-39 ET Docket No 13-84 at page 4 para.6:

> Since the Commission is not a health and safety agency, we defer to other organizations and agencies with respect to interpreting the biological research necessary to determine what levels are safe. As such, the commission invites health and safety agencies and the public to comment on the propriety of our general present limits and whether additional

> precautions may be appropriate in some cases, for example with respect to children. We recognize our responsibility to both protect the public from established adverse effects due to exposure to RF energy and allow industry to provide telecommunications services to the public in the most efficient and practical manner possible.

8. It is EMRPI's experience that the FCC's evaluation of the science on human exposure to low-intensity RF emissions is stalled in the late 1980s. EMRPI calls on FCC to consider BWG's work throughout the past decade in evaluating the continuing developments in EMR human and environmental exposure science, especially the studies on the biological effects of low-intensity, chronic, long-term exposure.

9. BWG is recognized internationally as expert in this area of science. EMRPI also requests that the FCC study the makeup and deliberations of the IARC Working Group resulting in the June 2011 Monograph on the *Carcinogenicity of radiofrequency electromagnetic fields.* See: http://monographs.iarc.fr/ENG/Monographs/vol102/index.php Some of those IARC Working Group members were or are US federal scientists, and several are co-authors of *The BioInitiative Report* and members of BWG as well.

10. EMRPI encourages the FCC to avail itself of BWG as a resource to evaluate "the propriety of our [FCC's] general present limits and whether additional precautions may be appropriate in some cases, for example with respect to children" and "with respect to interpreting the biological research necessary to determine what levels are safe."

11. EMRPI calls on the FCC to include the findings of ET Docket No. 16-191 FCC Technical Advisory Council (TAC) Public Inquiry to Investigate Changes to Radio Spectrum Noise Floor. EMRPI submitted Comment in that proceeding and it is found below. EMRPI includes the statement of Professor Gary Olhoeft PhD in that proceeding as Addendum II.

12. Radio Spectrum Noise is another term for electromagnetic interference (EMI). It is the non-biological, low-intensity environmental EMR effect that the FCC must address because local government and states have no authority to do so. The FCC has released no document to indicate that this inquiry has accomplished its goal and has carried out testing to describe

accurately the "radio spectrum noise floor" it seeks to quantify and describe. So, again this renders premature the speeding up of small cell facilities siting.

13. It is not clear to EMRPI that filings submitted in ET Docket No. 16-191 have been seen by the authors of WT Docket No. 16-421, so we are providing our Comment here:

In the Matter of	)	
FCC Technical Advisory Council (TAC)	)	
Public Inquiry to Investigate Changes to	)	ET Docket No. 16-191
Radio Spectrum Noise Floor	)	

To: Office of the Secretary
Federal Communications Commission
Washington, DC 20554

Comment Filed by: The EMRadiation Policy Institute
P.O. Box 117
Marshfield VT 05658
E-Mail: info@emrpolicy.org
Telephone: (802) 425-3035

August 11, 2016

The EMRadiation Policy Institute (EMRPI) endorses the Comment filed in this proceeding by Gary R. Olhoeft, SBEE, SMEE, PhD (Physics), Professor Emeritus of Geophysics at the Colorado School of Mines. Professor Olhoeft has a long and distinguished career in the areas of applied physics and electronics including serving at the United States Geological Survey (USGS) as Chief of Branch of

Petrophysics and Remote Sensing, including paleomagnetism and the geomagnetic observatories.

The FCC Public Notice at the release of this proceeding states that the goal of this inquiry is "to determine if there is an increasing noise problem, and if so, the scope and quantitative evidence of such problem(s) and how a noise study should be performed." If this goal is to be achieved and a meaningful study is to be carried out, the FCC must assemble a group of experts who possess a broad enough knowledge base to ask the pertinent questions and to collect meaningful data as Professor Olhoeft's Comment delineates. Olhoeft lays out the very complex nature of the interplay between the geology, biology, technology and engineering elements necessary to describe accurately the "radio spectrum noise floor" the FCC seeks to quantify and describe.

The American public urges the FCC to carry out a meaningful study of the questions this inquiry raises in order to lead to meaningful public policy. At issue is the question of interference with all manner of electronic devices as well as with the users of those devices and the natural and man-made ecosystems in which devices, users and all life coexist. Olhoeft's Comment references some measurement studies that have been done. Much more work is needed to keep up with the exponential increase in spectrum deployment the wireless revolution has brought.

Respectfully submitted by
The EMRadiation Policy Institute
Janet Newton

Janet Newton, President
P.O. Box 117
Marshfield VT 05658
e-mail: info@emrpolicy.org
Telephone: (802) 426-3035omment in

Addendum I – Comment in WT Docket 16-421 on behalf of The BioInitiative Working Group

Addendum II - Comment in ET Docket No. 16-191 of Gary R. Olhoeft, SBEE, SMEE, PhD

Addendum I

FCC 16-421

Before the Federal Communications Commission

Washington, D.C. 20554

In the Matter of

STREAMLINING DEPLOYMENT OF SMALL CELL INFRASTRUCTURE BY IMPROVING WIRELESS FACILITIES SITING POLICIES	)))	FCC Docket 16-421

To: Office of the Secretary
Federal Communications Commission, Washington, DC 20554

Date: 6 February 2017

Comment filed by: Cindy Sage, MA, Lennart Hardell, MD, PhD and David O. Carpenter on behalf of the BioInitative Working Group.

Cindy Sage, MA, Sage Associates, 1396 Danielson Road, Santa Barbara, CA 93108 USA
Email: sage@silcom.com
Prof. Lennart Hardell, MD, PhD. Department of Oncology Orebro University Hospital Orebro, Sweden. E-mail: lennart.hardell@regionorebrolan.se
David O. Carpenter, MD, 5 University Place, Room A-217, University at Albany, Rensselauer, NY 12144. Email: dcarpenter@albany.edu

The BioInitiative Working Group Comment on
FCC Docket 16-421 - STREAMLINING DEPLOYMENT OF SMALL CELL INFRASTRUCTURE BY IMPROVING WIRELESS FACILITIES SITING POLICIES

The FCC is proposing to streamline the process for small wireless facility permitting, without completing its investigation of RF health effects of low-intensity radiofrequency radiation (Docket No. 13-39, Docket No 13-84 - In the Matter of Reassessment of Federal Communications Commission Radiofrequency Exposure Limits and Policies and Docket No. 03-137 Regarding Human Exposure to Radiofrequency Electromagnetic Fields). This fact alone argues against the FCC speeding and easing the approval of millions of new 'small cell' wireless antenna sites under **Docket 16-421**. It also argues against permitting thousands of new satellite RF sources (Boeing **Docket No. 16-1244,** SAT-LOA-20160622-00058).

Health consequences have not been identified nor been factored into public safety limits. This is particularly true for the new 5G wireless technologies using millimeter wave frequencies (~28 GHz to ~71 GHz) that will be transmitted by small cells in the future. Adey (1993) warns:

> "*Biomolecular and cell research in this spectral region has been meager. There may be special significance to biomolecular interactions with millimeter wave EM fields. At frequencies within the range 10-1,000 GHz, resonant vibrational or rotational interactions, not seen at lower frequencies, may occur with molecules or portions of molecules.*"
>
> "*Grundler and Kaiser (1992) have shown that growth appears finely "tuned" to applied field frequencies around 42 GHz, with successive peaks and troughs at intervals of about 10 MHz. In recent studies, they noted that the sharpness of the tuning increases as the intensity of the imposed field decreases; but the tuning peak occurs at the same frequency when the field intensity is progressively reduced. Moreover, clear responses occur with* ***incident fields as weak as 5 picowatts/cm2.*** *" **(emphasis added)***

New public safety limits taking into account non-thermal, low-intensity effects of chronic exposure to 900 MHz to the low GHz frequencies are vitally needed but the FCC has failed to complete this step. There is no basis for the FCC to make a positive assertion of safety of existing RF levels to which the public is perpetually exposed. Certainly unaddressed health concerns should stop the FCC from expediting new wireless technologies facilitating new small cell siting and satellite RF sources. The existing FCC public safety limits are grossly inadequate

to protect public health from the body burden of the existing proliferation of RF-emitting devices and the wireless infrastructure supporting them, let alone from new RF sources that will make the situation worse for public health. There is a broad consensus that new, biologically-based public safety limits for chronic exposure are warranted, given the scientific and public health evidence for health risks from low-intensity radiofrequency radiation exposures from wireless technology applications (BioInitiative 2007 and 2012 Reports, accessed at www.bioinitiative.org).

The 2008 NAS Report on Research Needs for Wireless Device summarizes deficiencies for wireless effects on children, adolescents and pregnant women; wireless personal computers and base station antennas; multiple element base station antennas under highest radiated power conditions; hand-held cell phone compliance testing; and better dosimetric absorbed power calculations using realistic anatomic models for both men, women and children of different height and ages. Realistic assessments of cumulative RF exposures need to be addressed, taking into account the high variability in environmental situations; and safety buffers below 'effects levels' need to be built into new FCC public safety limits. The FCC has failed to do so. Instead the agency has sold off new spectrum, fails to complete its open reviews on RF health effects, and now proposes to fast-track application procedures for new RF sources.

The FCC ignores studies establishing human health harm at currently permissible exposure levels. The National Toxicology Program under the National Institutes of Health has completed the largest-ever animal study on cell phone radiation and cancer. The relationship between radiofrequency radiation and cancer is clearly established. Dr. John Bucher, Associate Director of the NTP and the lead researcher on this study confirmes that the exposure of 1.5 W/Kg is lower than currently allowed for the public, including children, under FCC public safety limits. Testing on rats is standard in predicting human cancers.

The NTP results confirm that cell phone radiation exposure levels within the currently allowable safety limits are the "likely cause" of brain and heart cancers in these animals. Tumors called schwannomas were induced in the heart. Hyperplastic lesions and glial cell neoplasms of the heart and brain observed in male rats are considered likely the result of whole-body exposures to GSM- or CDMA-modulated RFR. One in twelve (12) male rats developed either malignant cancer (glioma) and rare heart tumors. Pre-cancerous lesions were observed that can lead to cancer. The NTP says it is important to release these completed findings now given the implications to global health. No cancers occurred in the control group. The animal study confirms prior findings in epidemiological studies of an increased risk for glioma and acoustic

neuroma among people that use wireless phones, both cell phones and cordless phones (DECT). Acoustic neuroma is a type of Schwannoma, so interestingly this study confirms findings in humans of increased risk for glioma and acoustic neuroma. This supports upgrading the risk in humans to Group 1, the agent is carcinogenic to humans. The NTP evidence has filled the gap on animal toxicity of RF, and has greatly strengthening the evidence of risk for humans. It is sufficient to reclassify cell phone radiation as a known cancer-causing agent, and confirms the inadequacy of existing public safety limits.

The FCC needs to consider mounting evidence that even Wi-Fi level exposures are reported to cause DNA damage, brain damage and heat-shock protein (Dushmukh et al, 2017). The authors report statistically significant effects of subchronic low level microwave radiation (MWR) on cognitive function, heat shock protein 70 (HSP70) level and DNA damage in brain of Fischer rats. Experiments performed on male Fischer rats exposed to microwave radiation for 90 days at three different frequencies: 900, 1800, and 2450 MHz. Animals were exposed to microwave radiation at 900 MHz and specific absorption rate (SAR) 0.0005953 W/kg; animals exposed to 1800 MHz at SAR 0.0005835 W/kg and animals exposed to 2450 MHz at SAR 0.0006672 W/kg. These exposures are roughly equivalent to 1.5 to 2 uW/cm2. All the animals were tested for cognitive function using elevated plus maze and Morris water maze at the end of the exposure period and subsequently sacrificed to collect brain tissues. HSP70 levels were estimated by ELISA and DNA damage was assessed using alkaline comet assay. Results showed microwave exposure at 900-2450 MHz with SAR values as mentioned above lead to decline in cognitive function, increase in HSP70 level and DNA damage in brain. They conclude that low level microwave exposure at frequencies 900, 1800, and 2450 MHz may lead to hazardous effects on brain.

Evidence from microRNA studies at Wi-Fi intensities report damage, i.e., modulation of microRNA is presented by Dasdag et al. (2015a, 2015b) in new studies on 900 MHz cell phone radiation and 2450 MHz Wi-Fi levels of exposure. Dasdag et al. (2015b) report that very low intensity Wi-Fi exposures over a year-long period (24 hrs per day) at 141.4 uW/Kg (whole body SAR) and a maximum SAR of 7127 uW/Kg lowered activity of microRNAs in the brain of adult rats. Van den Hove et al. (2014) previously reported miR-107 as epigenetically-regulated miRNA linked to Alzheimer's disease and correlated with changes in neuronal development and neuronal activity.

The scientific evidence is more than sufficient in 2007, and certainly in 2012 (www.bioinitiative.org) that the Commission has not struck the right balance between uncontrolled wireless rollout and health impacts resulting for Americans, particularly for children. The increased risk for cancers, neurological diseases, memory and learning impairment in children, and other serious medical problems associated with wireless technologies and chronic exposure to low-intensity RF are now clearly available to the Commission.

The FCC should not approve streamlining the process for small wireless cell rollout, nor expedite any other approval process for siting of wireless facilities, nor grant exemptions for any RF source or low-power device or enabling network. The incremental increase in daily RF exposure already exceeds human health tolerance. Cumulative effects of RF exposures from multiple wireless devices and environmental exposures are not addressed at all; nor measured or tested under current or proposed FCC rules.

Respectfully submitted:

Cindy Sage, MA, Lennart Hardell, MD, PhD and David O. Carpenter, MD

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Editors

Cindy Sage, MA
David O. Carpenter, MD
BioInitiative 2007 and 2012 Reports

Contributing Authors of the the 2007 and 2012 BioInitiative Working Groups

Jitendra Behari, PhD, India
Carlo V. Bellieni, MD, Italy
Igor Belyaev, Dr.Sc., Slovak Republic
Carl F. Blackman, PhD, USA
Martin Blank, PhD, USA
Michael Carlberg, MSc, Sweden
David O Carpenter, MD, USA
Zoreh Davanipour, DVM, PhD USA
Adamantia F. Fragopoulou, PhD, Greece
David Gee, Denmark
Yuri Grigoriev, MD, Russia
Kjell Hansson Mild, PhD, Sweden
Lennart Hardell, MD, PhD, Sweden
Martha Herbert, PhD, MD, USA
Paul Héroux, PhD, Canada
Olle Johansson, PhD, Sweden
Michael Kundi, PhD, Austria
Henry Lai, PhD, USA
Ying Li, PhD, Canada
Abraham R. Liboff, PhD, USA
Lukas H. Margaritis, PhD, Greece
Henrietta Nittby, MD, PhD, Sweden
Gerd Oberfeld, MD, Austria
Bertil R. Persson, PhD, MD, Sweden
Iole Pinto, PhD, Italy
Paulraj Rajamani, PhD, India
Cindy Sage, MA, USA
Leif Salford, MD, PhD, Sweden
Eugene Sobel, PhD, USA
Amy Thomsen, MPH, MSPAS, USA

Addendum II

FCC Comment for ET Docket No. 16-191 by Gary R. Olhoeft, PhD, Professor Emeritus, CSM

Gary R. Olhoeft, SBEE, SMEE, PhD (Physics)
Professor Emeritus of Geophysics
Colorado School of Mines
Golden, CO 80401
golhoeft@mines.edu
(former USGS Chief of Branch of Petrophysics and Remote Sensing, including paleomagnetism and the geomagnetic observatories)

The FCC Office of Engineering and Technology Technical Advisory Council has requested comment on a variety of issues related to radio spectrum noise and changes to the spectrum noise floor over the last 20 years.

It specifically requests answers to questions concerning a variety of sources of anthropogenic device noise, "Noise denotes unwanted radiofrequency (RF) energy from man-made sources." In this limited context, it ignores the highly variable natural sources of noise from the magnetic and electrical fields of the Earth, sun, solar wind and their mutual interactions, as well as the interactions between devices and the Earth's surface, atmosphere and natural field processes. It also ignores changes that occur with time such as the solar sunspot cycle, or corrosion of earth grounding systems, but also as the devices themselves age (for example, allowable microwave oven leakage is only specified at the sale of a new device.)

Variations in the Earth's natural magnetic field amplitude and orientation have been recorded at low frequencies by magnetic observatories around the world since 720 AD in China and about 1510 in Europe (more details may be found in Merrill and others, 1996; see also Krider and Roble, 1986, Kelley, 2013). See Figure 1 for an example. Magnetic observatories are operated around the world by a variety of organizations (in the US by the USGS and NOAA) and coordinated by INTERMAGNET (http://www.intermagnet.org). Few magnetic observatories also record electric fields, and fewer still record continuous spectra into the radiofrequency range (Figures 2 and 3). One example that does so is the National Radio Quiet Zone for radioastronomy (https://science.nrao.edu/facilities/gbt/interference-protection/nrqz). See also http://www.its.bldrdoc.gov/resources/table-mountain/tm-home.aspx. There are now over 100 radioastronomy quiet zones around the world: https://www.google.com/maps/d/viewer?mid=1HX_7mIUcmDybmsONe9hIGisMOhc&hl=en). These magnetic observatories also monitor (along with NASA and NOAA satellites) solar magnetic and radio storms that impact commercial FAA and U.S. Air Force air traffic control operations (http://www.spaceweather.com), and interfere with GPS, pager, cellular systems, and the power grid (Centra Technology Inc., 2011).

I would also note that since the 1950's, the USGS has mapped soil properties (see Figure 4) for the FCC to better site radio stations. These are also used by the U.S. Navy and U.S. Coast Guard to better locate LORAN and submarine communications facilities. The USGS has also been asked to explain why transmitter antenna patterns change with varying water table depth, changing snow or permafrost conditions, and other environmental parameters. Much of this data is hard to find as many subject matter experts are retired.

FCC Comment for ET Docket No. 16-191 by Gary R. Olhoeft, PhD, Professor Emeritus, CSM

In addition to my comments above, here are my answers to the questions posed along with a few added questions that should have been asked, but were not. My answers are in **bold** brackets.

1. Is there a noise problem? **[Yes, but it depends upon how you define "noise." I would not limit the sources of noise to man-made devices.]**

a. If so, what are the expected major sources of noise that are of concern?

[Just about anything electrical, including RFID, electronic inventory control systems, WiFi, smart meters, remote control drones, cell phones and base stations, automated vehicle systems, robots, lighting systems, arc welders, security devices, lightning, solar storms, large single point transmitters, distributed transmitting systems, electric transit systems, wireless charging and power transmission systems.]

b. What services are being most impacted by a rising spectrum noise floor?

[Function of medical implants (including cardiac pacemakers and neurostimulators), geophysical instruments used for infrastructure location and characterization, agricultural crop and soil moisture monitors, resource exploration, geolocation services, automated systems (vehicles, robots, drones).]

c. If incidental radiators are a concern, what sorts of government, industry, and civil society efforts might be appropriate to ameliorate the noise they produce?

[Allow as little as possible RF through the air. Instead use underground shielded conduits, fiber optics, point to point LiFi, UWB low power pulses. Use shielding, ferrites and filters to isolate homes and schools. Ban transmitters inside vehicles, schools and homes. Require FDA certification (the FDA covers a wider range of frequencies than the FCC) for new technologies.]

2. Where does the problem exist?

a. Spectrally

i. What frequency bands are of the most interest?

[All, below 1 Hz to above 10 GHZ]

b. Spatially

i. Indoors vs outdoors? **[Both, and also in or near vehicles. Buildings or elevators may act as waveguides, enhancing the effects (multipathing and waveguide effects have also been reported from natural geological structures.) Corroding grounds and grounding systems struck by lightning change noise with time requiring periodic noise re-surveys.]**

ii. Cities vs rural settings? **[Both, with earth-ionosphere waveguide enhancement, and topographic and building multipathing.]**

iii. How close in proximity to incidental radiators or other noise sources?

[Depends upon wavelength and sensitivity, amplitude and duration.]

iv. How can natural propagation effects be accounted for in a noise study?

[Modeling, and better models are needed, including better descriptions of properties and processes in soils, ecosystems, buildings, streets, infrastructure.]

c. Temporally?

i. Night vs day? **[associated changes in ionosphere, soil and atmospheric moisture]**

ii. Seasonally? **[see below]**

[iii. Soil type? Moisture content? Thawed vs frozen? Bare soil and rock vs plant vs asphalt and concrete covered? Surface and volumetric roughness? Frequency dependence? Magnetic soil or rock? Corroding earth grounds changing with time? Nonlinear effects? Evapotranspiration?]

FCC Comment for ET Docket No. 16-191 by Gary R. Olhoeft, PhD, Professor Emeritus, CSM

3. Is there quantitative evidence of the overall increase in the total integrated noise floor across various segments of the radio frequency spectrum? **[Yes.]**

a. At what levels does the noise floor cause harmful interference to particular radio services? **[Varies with service and location.]**
[Does this include NRAO and biological/ecosystem effects?]

b. What RF environment data from the past 20 years is available, showing the contribution of the major sources of noise? **[USGS, NOAA, NASA solar wind.][NRAO NRQZ NIST][World Data Centers][Some data go back to the 1950's, but high quality RF data only exist since 1980.]**

c. Please provide references to scholarly articles or other sources of spectrum noise measurements. **[Representative references are given below at end.]**

4. How should a noise study be performed? **[Many answers depend on how you define "noise"; a few representative answers are given.]**

a. What should be the focus of the noise study? **[See USAF, 2009, and Gruber, 2010; and emissions from newest technology such as robotic vehicles that might interfere with each other.]**

b. How should it be funded? **[Non-regulatory government agency.]**

c. What methods should be used? **[Holloway and others, 2001.]**

d. How should the noise be measured? **[Tensor electric and magnetic fields vs frequency in continuous observatory recordings.][Use multiple locations as water tables move, seasons change, etc.]**

i. What is the optimal instrumentation that should be used? **[Spectrum analyzers and transmit-receiver path characterization as in Holloway and others, 2001; Labson and others, 1985; referenced against properly shielded rooms.]**

ii. What measurement parameters should be used for that instrumentation?

iii. At what spatial and temporal scales should noise be measured?

iv. Should the monitoring instrumentation be capable of determining the directions of the noise sources? If so, how would those data be used? **[Yes; to determine sources and backtrack source and path location and characteristics for modeling to other situations or locations.]**

v. Is there an optimal height above ground for measurements? **[Varies; some should be underground or inside buildings.]**

e. What measurement accuracy is needed?

i. What are the statistical requirements for sufficient data?

ii. Can measurements from uncalibrated, or minimally calibrated, devices be combined?

iii. Is it possible to "crowd source" a noise study?

f. Would receiver noise measurements commonly logged by certain users (e.g., radio astronomers, cellular, and broadcast auxiliary licensees) be available and useful for noise floor studies? **[Yes] [NRQZ] [ARRL?]**

g. How much data must be collected to reach a conclusion? **[Several solar sunspot cycles.]**

h. How can noise be distinguished from signals? **[Depends on definition of "signal" vs "noise".]**

i. Can noise be characterized and its source identified?**[Yes]**

ii. Is there a threshold level, below which measurements should be ignored?
[See Figure 2]

FCC Comment for ET Docket No. 16-191 by Gary R. Olhoeft, PhD, Professor Emeritus, CSM

References (representative, not comprehensive, insufficient time to collect more)

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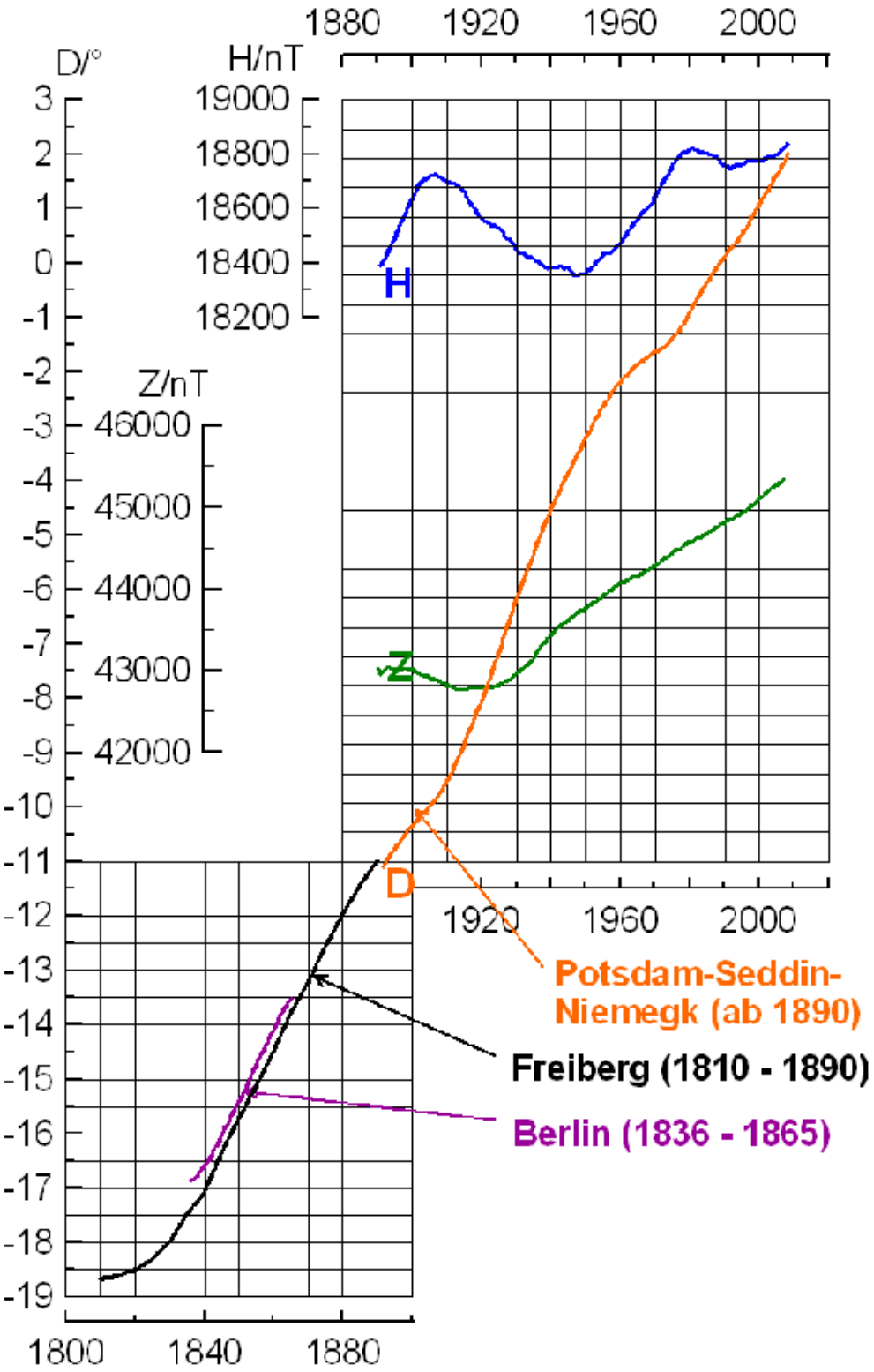

Figure 1 An example of the Earth's changing magnetic field versus time recorded at German observatories. H is horizontal field amplitude, Z is vertical field amplitude, and D is declination. This is low frequency (below 1 Hz) data, higher frequencies were not recorded until the 1950's.

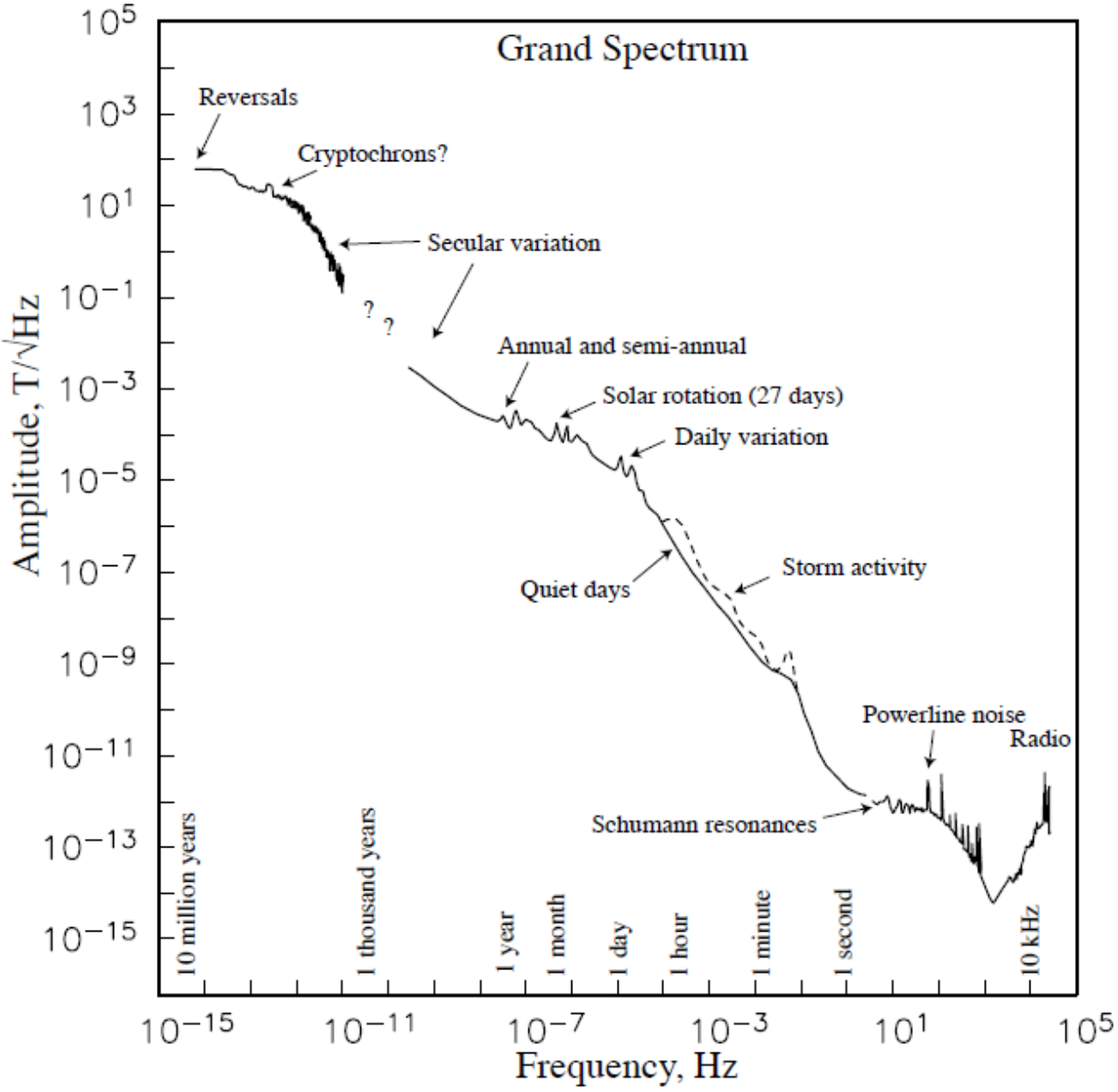

Figure 2 An example composite amplitude spectrum of geomagnetic variations (Constable and Constable, 2004) with annotations indicating the various physical processes from the earth, sun and solar wind interactions. Note the higher frequencies are dominated by man-made sources.

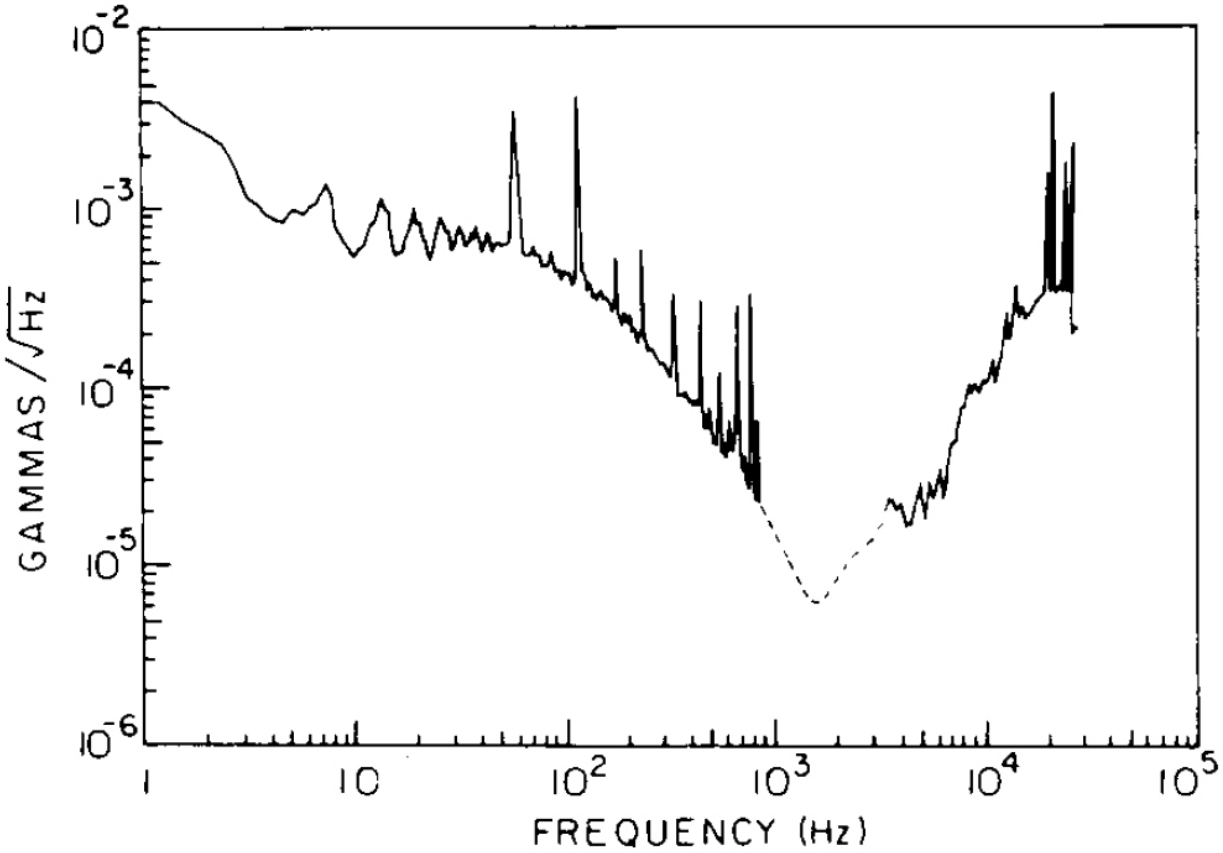

Figure 3 Expanding highest frequencies of Figure 2 (from Labson and others, 1985) to show the dominant effects of powerline and radiofrequencies over natural noise sources. Note this figure changes with location, time of day, season, weather, soil properties and other factors. The original caption reads, “Typical summer spectrum at San Antonio Valley, California, July 14, 1980”.

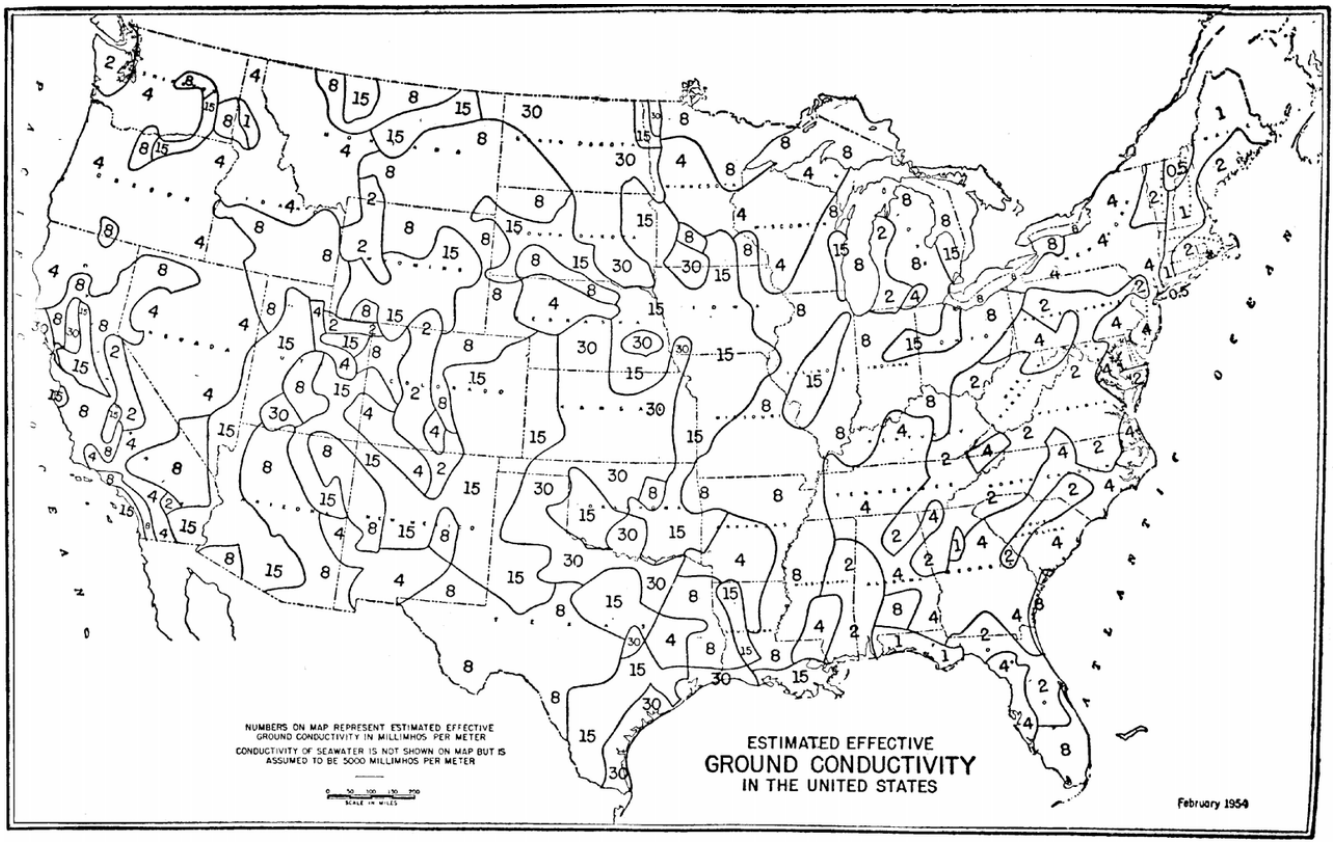

Figure 4 February 1954 FCC Ground conductivity map without regard to soil type, moisture content, temperature, seasonal variation, frequency dependence or other relevant factors, still in use today (accessed August 2016):
https://www.fcc.gov/media/radio/m3-ground-conductivity-map